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Character association and path coefficient analysis in rose (*Rosa* × *hybrida*)

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ABSTRACT

The present investigations on association of various morphological traits through correlation and path coefficient analysis were carried out among 32 rose *Rosa* × *hybrida* cultivars. The path coefficient analysis provided information about direct and indirect effect of examined characteristics on number of flowers per plant. The statistically significant and positive correlation (genotypic and phenotypic) was observed for primary branches with number of flowers per plant, whereas it was non significant and positive for secondary branches (genotypic and phenotypic), bud length (phenotypic) and internodal length (genotypic). The statistically significant and negative correlation (genotypic and phenotypic) was observed for neck length, flower diameter and flower weight with number of flowers per plant. Path coefficient (genotypic) analysis revealed maximum positive direct effect on number of flowers per plant by stem girth, followed by flower diameter, primary branches, days to flowering, bud length and number of petals per flower whereas phenotypic path coefficient analysis revealed highest and significantly positive direct effect on number of flowers per plant by secondary branches followed by flower diameter, bud length, stalk length, primary branches, number of petals per flower, plant height, stem girth and days to flowering.

Key words: Correlation coefficient, path coefficient analysis, rose.

INTRODUCTION

Rose (*Rosa* × *hybrida*) is one of the most economically important ornamental species used as landscape and cut flower plant in the world. Among cut flowers, rose ranks first in terms of trade and popularity. Rose plays a vital role in manufacturing of various products of medicinal and nutritional importance. However, a very peculiar aspect of rose production is to get the cut flowers, which greatly deals with the floricultural business. An effective breeding programme for developing improved quality varieties requires preliminary information on the nature and magnitude of genetic variability, degree of transmission of traits and their inter-relationship. Hence, it is important to have the knowledge of association of vegetative and floral traits among themselves. Correlation coefficient studies are useful in choosing superior cultivars from their phenotypic and genotypic expression. As far as flower yield is concerned, it is a complex trait known to be collectively influenced by various polygenically inherited traits. Therefore, correlation studies give an idea about the positive and negative associations of different vegetative and floral traits with number of flowers per plant and also among themselves. However, using correlation coefficient studies, nature and extent of contribution by these traits towards number of flowers per plant is not obtained. This difficulty is overcome by path coefficient studies, it facilitates partitioning of correlation coefficients into direct and indirect effects of the different traits on number of flowers per plant or any other traits and also helps in finding out how these effects influence a particular character to produce a given positive or negative correlation. The information helps in giving proper weightage to various traits during selection or other breeding programme so that the improvement of desirable trait could be achieved effectively. Keeping these points in view, the present studies were carried out to find out the inter-relationship among the component responsible for more number of flowers per plant, *i.e.* flower yield per plant and the direct and indirect influences of each of the component trait towards number of flowers per plant.

MATERIALS AND METHODS

The planting materials consisting of indigenously bred 32 rose cultivars were included in the study (Table 1). Of which, 16 belongs to Hybrid Tea and 16 to Floribunda groups. The analysis was carried out for 15 growth and flowering related traits. The experiment was laid out in a randomized block design with three replications at Research Farm, Division of Floriculture and Landscaping, IARI, New Delhi. The experiment was conducted in open field at spacing of 60 cm × 60

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Table 1. Rose genotypes representing Hybrid Tea and Floribunda groups.

Genotype	Group	Parentage
Raktima	Hybrid Tea	Pink Parfait × Sugandha
Raktagandha	Hybrid Tea	Christian Dior × Seedling of Carrousel
Lalima	Hybrid Tea	Picture × Jour
Pusa Arun	Hybrid Tea	Queen Elizabeth × Jantar Mantar
Pusa Mohit	Hybrid Tea	Suchitra × Christian Dior
Indian Princess	Hybrid Tea	Super Star × Granada
Dr S.S. Bhatnagar	Floribunda	Oklahoma × White Christmas
Jantar Mantar	Floribunda	-
Jawahar	Hybrid Tea	Sweet Afton × Delhi Princess
Mrs. K.B. Sharma	Hybrid Tea	White Masterpiece × Michele Meilland
Shabnam	Floribunda	Seedling of Baby Sylvia
Navneet	Floribunda	Prelude × Africa Star
Himangini	Floribunda	Seedling of Saratoga
Ganga	Hybrid Tea	Seedling of Sabine
Raja Ram Mohan Roy	Hybrid Tea	-
Pusa Pitambar	Floribunda	Jantar Mantar × Banjaran
Haseena	Hybrid Tea	Youki San × Balinese
Dr Benjamin Pal	Hybrid Tea	Sweet Afton × First Prize
Pusa Ajay	Hybrid Tea	Pink Parfait × Queen Elizabeth
Sadabahar	Floribunda	Seedling of Frolic
Pusa Barahmasi	Floribunda	Seedling of Sadabahar
Pusa Ranjana	Floribunda	Pink Parfait × Iceberg
Surkhab	Hybrid Tea	-
Chingari	Floribunda	Seedling of Charleston
Lahar	Floribunda	Pink Parfait × Ganga
Pusa Manhar	Floribunda	Jantar Mantar × Lahar
Raja Surendra Singh of Nalagarh	Hybrid Tea	Scarlet Knight × Montezuma
Jawani	Hybrid Tea	Scarlet Queen Elizabeth × Louisiana
Suryodaya	Floribunda	Seedling of Orangeade
Suryakiran	Floribunda	-
Deepak	Floribunda	-
Shola	Floribunda	Seedling of Anna Wheatcroft

cm and recommended cultural practices were carried out to raise a healthy crop. The observations were recorded on 10 random competitive plants from each replication after discarding the side/border plants. The cultivars were assessed and data was recorded for various vegetative and floral traits, *i.e.* plant height (cm), number of primary branches, number of secondary branches, stem girth (cm), prickle density (number per 5 cm of stem length), internodal length (cm), leaf area (cm^2), days to first flowering, bud length (cm), stalk length (cm), neck length (cm), flower diameter (cm), flower weight (g), number of petals per flower and number of flowers per plant.

The genotypic and phenotypic correlation coefficients were determined among all possible combinations of traits by considering the appropriate variance and co-variance. Path coefficient analysis was done by the following methodology suggested by Wright (17) and using the formula given by Dewey and Lu (5) in order to measure the direct influence of one variable upon the other and to partition the total correlation into direct and indirect effects.

RESULTS AND DISCUSSION

The statistically significant and positive correlation (genotypic and phenotypic) was observed for primary branches (0.392 and 0.362) with flower yield, whereas it was non significant and positive for secondary branches (genotypic and phenotypic), bud length (phenotypic) and intermodal length (genotypic) in present study (Tables 2&3). Statistically significant and positive correlation (genotypic and phenotypic) for number of branches with number of flowers per plant has been reported in dahlia by Chaudhary (3). Similarly, internodal length is positively correlated with number of flowers in anthurium (Binodh *et al*., 2). Bud length is positively correlated with flower yield per plant as reported in rose by Manjula (8). Statistically significant and negative correlation (genotypic and phenotypic) was observed for neck length (-0.577 and -0.504), flower diameter (-0.534 and -0.476) and flower weight (-0.427 and -0.373) with number of flowers per plant. The significant and negative genotypic correlation was also observed for leaf area (-0.370) and negative phenotypic correlation for internodal length (-0.517) with flower yield (Tables 2&3). Similar findings have also been reported in gladiolus for diameter of floret with marketable spike per plant by Rashmi (11). The negative correlation between flower diameter and number of flowers per plant observed in this study is in accordance with the findings of Chaudhary (3) in dahlia; Verma *et al*. (15) in rose; and Namita *et al*. (9) in marigold.

Since rose is grown for its ornamental and landscape characteristics, therefore apart from its flower yield, other traits, *viz*., stalk length, neck length, internodal length, bud length, flower diameter, flower weight, number of petals per flower, prickle density etc. which contribute to its ornamental value, are also of paramount importance. Therefore, correlation analysis was done to find out association of growth and flowering traits among themselves. From the present study, positive and significant association with greater magnitude was observed for many growth and flowering traits. Some of the positive and significant associations (genotypic and phenotypic) was reported between plant height and stalk length (0.511 and 0.423), which is in accordance with the findings of Namita *et al.* (9), and Singh and Saha (13) in marigold; Manjula (8) in rose. Similar association was also recorded for flower diameter and flower weight (0.693 and 0.649), which is similar to the findings as reported in African marigold (Karuppaiah and Kumar, 7), dahlia (Vikas *et al*., 16), and rose (Verma *et al*., 15). Number of petals was positively and significantly correlated with flower weight (0.441 and 0.419) in our study and Tabaei (14) also reported that number of petals was positively correlated with flower weight in *Rosa damascena* Mill.

Similarly significant negative associations were observed for many growth and flowering traits. Some of associations (genotypic and phenotypic) in these traits like plant height with days to flowering (-0.441 and -0.361), which is in accordance with the findings of Namita *et al*. (9) in marigold; Manjula (8) in rose. Also significant negative association were observed for neck length with number of flowers per plant; flower diameter with number of flowers per plant and these findings are similar to the results as reported in marigold by Namita *et al.* (9), rose by Manjula (8) and chrysanthemum by Raghava *et al*. (10). These findings reveals that increase in flower size will reduce the total number of flowers per plant.

Significantly genotypic correlation between number of flowers per plant and other traits suggested that the genes which influence these growth and flowering traits will tend to influence the trait understudy (Dabohlkar, 4). The difference between genotypic and phenotypic correlation for each pair of trait studied indicated that there is environmental influence which mask the actual genotypic correlation. The higher genotypic correlation in magnitude than the phenotypic correlation coefficient indicating that there is strong association between various vegetative and floral traits studied. This association is mainly because of genetic and environmental sources of variation which affected the trait through different physiological mechanisms (Falconer, 6), pleiotropy, linkage and environmental effects being more common in experimental and breeding populations of cross fertilized one and in the population derived from crosses between inbred lines (Aastveit and Aastveit,1).

Path coefficient analysis (genotypic and phenotypic) was carried out by taking number of flowers per plant as a dependent character (Tables 4&5). The partitioning of genotypic correlation into direct and indirect effects revealed that the stem girth contributed (3.119) highest and significantly positive direct effect on number of flowers per plant followed by flower diameter, primary branches, days to flowering, bud length number of petals per flower, and stalk length. However, negative direct effect on number of flowers per plant were attributed by plant height (-1.522), secondary branches (-1.183), prickle density (-1.221), interModal length (-0.304), leaf area (-0.770), neck length (-0.531) and flower weight (-2.072) (Table 4). The findings of negative direct effect of plant height on flower yield are in accordance with the results as reported in marigold (Namita *et al*., 9). Our studies also reported positive correlation between intermodal length and number of flowers per plant but its direct effect was negative. Similar

Table 2. Genotypic correlation coefficient among different traits of rose.

Trait	Plant height (cm)	Primary branches (No.)	Secondary branches (No.)	Stem girth (cm)	Prickle density	Internodal length (cm)	Leaf area (cm^2)	Days to flowering	Bud length (cm)	Stalk length (cm)	Neck length (cm)	Flower diameter (cm)	Flower weight (g)	No. of petals/ flower	No. of flowers/ plant
Plant height (cm)	1.000	0.383**	0.315	0.747**	0.204	0.164	0.203	-0.441**	0.156	0.511**	0.323	0.376*	0.207	0.176	-0.054
Primary branches (No.)		1.000	0.649**	0.079	-0.043	0.202	0.253	-0.028	0.263	0.146	0.029	-0.001	-0.292	0.018	0.392**
Secondary branches (No.)			1.000	0.246	-0.115	0.212	-0.148	-0.183	0.172	0.188	0.230	0.166	-0.149	-0.018	0.133
Stem girth (cm)				1.000	0.580**	0.095	0.249	-0.470**	0.147	0.567**	0.299	0.508**	0.663**	0.378*	-0.267
Prickle density					1.000	-0.079	0.210	-0.012	0.100	0.219	0.026	0.251	0.370*	0.254	-0.158
Internodal length (cm)						1.000	0.123	0.020	0.530**	0.336	0.179	0.134	-0.067	0.055	0.097
Leaf area (cm^2)							1.000	0.266	0.344*	0.408**	0.411**	0.475**	0.424**	0.431**	-0.37*
Days taken to flowering								1.000	-0.093	-0.293	0.058	-0.043	-0.052	0.108	-0.169
Bud length (cm)									1.000	0.467**	0.430**	0.510**	0.286	-0.077	-0.303
Stalk length (cm)										1.000	0.548**	0.660**	0.487**	0.353*	-0.255
Neck length (cm)											1.000	0.817**	0.437**	0.094	-0.577**
Flower diameter (cm)												1.000	0.693**	0.119	-0.534**
Flower weight (g)													1.000	0.441**	-0.427**
No. of petals/ flower														1.000	-0.142
No. of flowers/ plant															1.000

*,** Significant at 5 and 1% levels

Table 3. Phenotypic correlation coefficient among different traits of rose.

Trait	Plant height (cm)	Primary branches (No.)	Secondary branches (No.)	Stem girth (cm)	Prickle density	Internodal length (cm)	Leaf area (cm^2)	Days to flowering	Bud length (cm)	Stalk length (cm)	Neck length (cm)	Flower diameter (cm)	Flower weight (g)	No. of petals/ flower	No. of flowers/ plant
Plant height (cm)	1.000	0.253	0.238	0.431**	0.181	0.139	0.148	-0.361*	0.143	0.423**	0.285	0.351*	0.205	0.165	-0.032
Primary branches (No.)		1.000	0.526**	0.112	0.020	0.063	0.212	-0.077	0.201	0.019	0.043	-0.004	-0.187	0.025	0.362**
Secondary branches (No.)			1.000	0.153	-0.081	0.118	-0.060	-0.154	0.164	0.160	0.168	0.104	-0.077	-0.016	0.179
Stem girth (cm)				1.000	0.287	0.032	0.087	-0.265	0.092	0.227	0.182	0.344*	0.393**	0.173	-0.033
Prickle density					1.000	-0.092	0.207	0.011	0.052	0.105	0.029	0.189	0.304	0.223	-0.131
Internodal length (cm)						1.000	0.110	-0.013	0.409**	0.296	0.165	0.126	-0.060	0.058	-0.517**
Leaf area (cm^2)							1.000	0.156	0.290	0.264	0.378*	0.380*	0.375*	0.369*	-0.27
Days taken to flowering								1.000	-0.106	-0.161	0.037	-0.033	-0.040	0.086	-0.039
Bud length (cm)									1.000	0.362*	0.408**	0.474**	0.226	-0.068	0.009
Stalk length (cm)										1.000	0.412**	0.537**	0.414**	0.300	-0.139
Neck length (cm)											1.000	0.782**	0.397**	0.095	-0.504**
Flower diameter (cm)												1.000	0.649**	0.115	-0.476**
Flower weight (g)													1.000	0.419**	-0.373**
No. of petals/ flower														1.000	-0.12
No. of flowers/ plant															1.000

*,** Significant at 5 and 1% levels

Table 4. Genotypic path coefficient analysis of different quantitative traits on number of flowers per plant.

Trait	Plant height (cm)	Primary branches (No.)	Secondary branches (No.)	Stem girth (cm)	Prickle density	Internodal length (cm)	Leaf area (cm^2)	Days to flowering	Bud length (cm)	Stalk length (cm)	Neck length (cm)	Flower diameter (cm)	Flower weight (g)	No. of petals/ flower	No. of flowers/ plant
Plant height (cm)	**-1.522**	0.31	-0.372	2.33	-0.249	-0.05	-0.156	-0.27	0.062	0.038	-0.172	0.364	-0.43	0.063	-0.054
Primary branches	-0.583	**0.809**	-0.71	0.24	0.076	-0.03	-0.102	-0.017	0.104	0.011	-0.015	-0.001	0.604	0.006	0.392
Secondary branches	-0.479	0.525	**-1.183**	0.767	0.141	-0.064	0.114	-0.112	0.068	0.014	-0.122	0.161	0.309	-0.006	0.133
Stem girth (cm)	-1.137	0.064	-0.291	**3.119**	-0.708	-0.029	-0.192	-0.288	0.058	0.042	-0.159	0.492	-1.373	0.135	-0.267
Prickle density	-0.31	-0.035	0.136	1.809	**-1.221**	0.024	-0.162	-0.007	0.04	0.016	-0.014	0.242	-0.766	0.09	-0.158
Internodal length (cm)	-0.249	0.163	-0.25	0.295	0.097	**-0.304**	-0.095	0.012	0.209	0.025	-0.095	0.13	0.139	0.02	0.097
Leaf area (cm^2)	-0.308	0.205	0.175	0.777	-0.257	-0.037	**-0.77**	0.163	0.136	0.03	-0.218	0.459	-0.879	0.154	-0.37
Days taken to flowering	0.671	-0.022	0.217	-1.466	0.015	-0.006	-0.205	**0.612**	-0.037	-0.022	-0.031	-0.041	0.108	0.038	-0.169
Bud length (cm)	-0.238	0.213	-0.203	0.457	-0.122	-0.161	-0.265	-0.057	**0.394**	0.034	-0.228	0.494	-0.593	-0.028	-0.303
Stalk length (cm)	-0.778	0.118	-0.223	1.768	-0.268	-0.102	-0.314	-0.179	0.184	**0.074**	-0.291	0.639	-1.009	0.126	-0.255
Neck length (cm)	-0.492	0.024	-0.272	0.931	-0.031	-0.054	-0.317	0.036	0.169	0.04	**-0.531**	0.791	-0.905	0.034	-0.577
Flower diameter (cm)	-0.572	-0.001	-0.197	1.584	-0.306	-0.041	-0.365	-0.026	0.201	0.049	-0.434	**0.968**	-1.437	0.043	-0.534
Flower weight (g)	-0.316	-0.236	0.176	2.067	-0.452	0.02	-0.327	-0.032	0.113	0.036	-0.232	0.671	**-2.072**	0.157	-0.427
No. of petals/ flower	-0.268	0.015	0.021	1.179	-0.31	-0.017	-0.332	0.066	-0.031	0.026	-0.05	0.115	-0.913	**0.357**	-0.142

Residual effect = 0.3982

Table 5. Phenotypic path coefficient analysis of different quantitative traits on number of flowers per plant.

Trait	Plant height (cm)	Primary branches (No.)	Secondary branches (No.)	Stem girth (cm)	Prickle density	Internodal length (cm)	Leaf area (cm^2)	Days to flowering	Bud length (cm)	Stalk length (cm)	Neck length (cm)	Flower diameter (cm)	Flower weight (g)	No. of petals/ flower	No. of flowers/ plant
Plant height (cm)	**0.062**	0.02	0.045	-0.018	-0.007	0.015	-0.002	0.012	-0.017	0.05	-0.12	-0.05	-0.009	-0.013	-0.032
Primary branches (No.)	0.035	**0.08**	0.099	-0.002	-0.001	0.087	-0.001	0.01	-0.01	0.068	-0.01	0.001	0.008	-0.002	0.362
Secondary branches (No.)	0.015	0.042	**0.188**	-0.006	0.003	0.013	0.001	0.005	-0.019	0.019	-0.071	-0.015	0.003	0.001	0.179
Stem girth (cm)	0.027	0.009	0.029	**0.042**	-0.011	0.004	-0.001	0.009	-0.011	0.027	-0.077	-0.049	-0.017	-0.014	-0.033
Prickle density	0.011	0.002	-0.015	-0.012	**-0.04**	-0.01	-0.003	-0.001	-0.006	0.012	-0.011	-0.027	-0.013	-0.018	-0.131
Internodal length (cm)	0.009	0.005	0.022	-0.001	0.004	**-0.451**	-0.002	-0.003	-0.045	0.035	-0.07	-0.018	0.003	-0.005	-0.517
Leaf area (cm^2)	0.009	0.017	-0.011	-0.004	-0.008	0.012	**-0.017**	-0.005	-0.034	0.031	-0.16	-0.054	-0.017	-0.029	-0.27
Days taken to flowering	-0.022	-0.006	-0.024	0.011	-0.005	-0.001	-0.003	**0.034**	0.012	-0.019	-0.016	0.005	0.002	-0.007	-0.039
Bud length (cm)	0.009	0.016	0.031	-0.004	-0.002	0.045	-0.005	0.004	**0.118**	0.042	-0.172	-0.068	-0.01	0.005	0.009
Stalk length (cm)	0.026	0.002	0.030	-0.01	-0.004	0.033	-0.004	0.006	-0.043	**0.117**	-0.174	-0.077	-0.018	-0.023	-0.139
Neck length (cm)	0.018	0.003	0.032	-0.008	-0.001	0.018	-0.006	-0.001	-0.048	0.048	**-0.422**	-0.112	-0.018	-0.007	-0.504
Flower diameter (cm)	-0.002	-0.001	-0.058	-0.037	-0.012	-0.068	-0.009	-0.01	-0.085	0.052	-0.331	**0.143**	-0.028	-0.03	-0.476
Flower weight (g)	0.013	-0.015	-0.014	-0.017	-0.012	-0.007	-0.006	0.001	-0.027	0.049	-0.168	-0.093	**-0.044**	-0.033	-0.373
No. of petals/ flower	-0.001	0.002	-0.023	-0.007	-0.039	-0.006	-0.008	-0.017	0.003	0.001	-0.04	-0.044	-0.019	**0.078**	-0.12

Residual effect = 0.4050

observation was also reported in anthurium by Binodh *et al*. (2). Shiva *et al.* (12) also reported negative direct effect of days to flowering on number of flowers per plant which is in confirmation with our studies. The partitioning of phenotypic correlation into direct and indirect effects revealed that the secondary branches contributed (0.188) highest and significantly positive direct effect on number of flowers per plant followed by flower diameter, bud length, stalk length, primary branches, number of petals per flower, plant height, stem girth and days to flowering. However, negative direct effect on number of flowers per plant were attributed by prickle density (-0.04), internodal length (-0.451), leaf area (-0.017), neck length (-0.422) and flower weight (-0.044).

This study indicates that stem girth, flower diameter, primary branches, days to flowering, stalk length are the primary traits for which selections can be exercised and plant height, prickle density, neck length and flower weight are the secondary traits in preference of selection, where selection for early types should be exercised.

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